A Macroinvertebrate IBI for the Assessment of Northeastern Lakes

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North American Lake Management Society
November, 2006

Purpose of today's discussion

- Overall approach for developing lake biocriteria
- A word about our database
- Classification approach and methods
- A macroinvertebrate IBI
- A phytoplankton IBI
- A 'RIVPACS' macroinvertebrate IBI (if time permits)

General multimetric IBI approach

- Reference-based approach
- Begin w/ no a-priori viewpoint on metrics
- Select reference and suspected-impacted sites
- Measure target community using appropriate toolkit
- Stratify measurements across habitats

General multimetric IBI approach

- Infer a biological classification of reference lakes (CA, CCA)
- Model the classification (DFA)
- Go fishing for metrics that discriminate reference from test lakes, while being sensitive to class
- Weed out redundant metrics
- Retain sensitive, independent metrics
- Score metrics, and create index
- Test index discrimination statistically

Description of the database

- 61 lakes assessed
- Lakes range widely in alkalinity, size, depth, trophic status, and level of disturbance.

	Lake Area ac	Basin Area ac	Max Dep m	ALK mg/l	COND us/cm	Flush Rate #/yr
Min	20	173	1.8	-0.3	9.2	0.4
Median	69	1,382	11.9	28.3	82.9	3.8
Mean	182	4,024	13.2	32.8	91.4	7.7
Max	1,402	89,292	43.0	103.5	305.5	52.1


Carmi
Clyde Pon
Nathan Po
Fairfield
McConnell
South St
North St
Eden, Lak
Lake Park
Crystal I
Great Hos
Shadow La
Long Pond
Maidstone
Sessions,
Colcheste
Indian Br
Wolcott P
Caspian L
Little El
Lyford Po
Curtis Po
Joes Pond
Stiles Po
Turtle Lea
Bliss Pon
Ticklenak
North Pon
Russell,
Lake Dunm
Sugar Hil
Hatch Pon
Intervale
Sunrise L
Hinkum Po
Jones Mil
Silver La
Chittende
Woodward
Butternut
Gilman Po
Spring La
Lake St.
Ninevah,
Wallingfo
Danby Pon
Smith Pon
French, N
Dudley
Branch Po
Stratton
Willard,
Pleasant
Broad Bro
Beaver La

Sampling approach

- Bioassessment visit takes ~1day
- Lakes visited during summer index period Aug 1 to Sept 15.
- Lake ‘trisected,’ the first occurrence of each target habitat sampled once in each third, these samples composited.
- Replication for QC purposes and to assess variability

Five macroinvertebrate habitats

- Rocky littoral
  - Timed sweep net search, 2 person, five minutes per person, at each third of the lake
- Muddy littoral
  - Sweep net, two one-meter sweeps @5cm deep, at each third of the lake
- Macrophyte beds
  - Sweep net, four sweeps thru plant beds, at each third of the lake

Five macroinvertebrate habitats

- Sublittoral
  - Eckman dredge, one grab at each third of the lake, composited to comprise a whole-lake sample
- Profundal
  - Eckman dredge, three grabs, composited, from the deepest hole of the lake.

Cartoon Lake

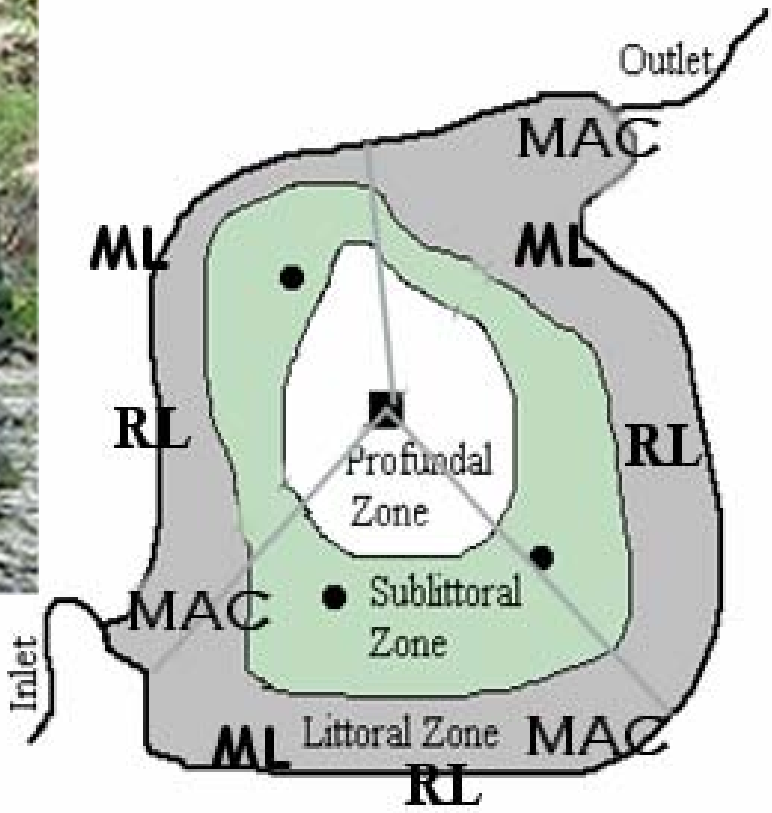
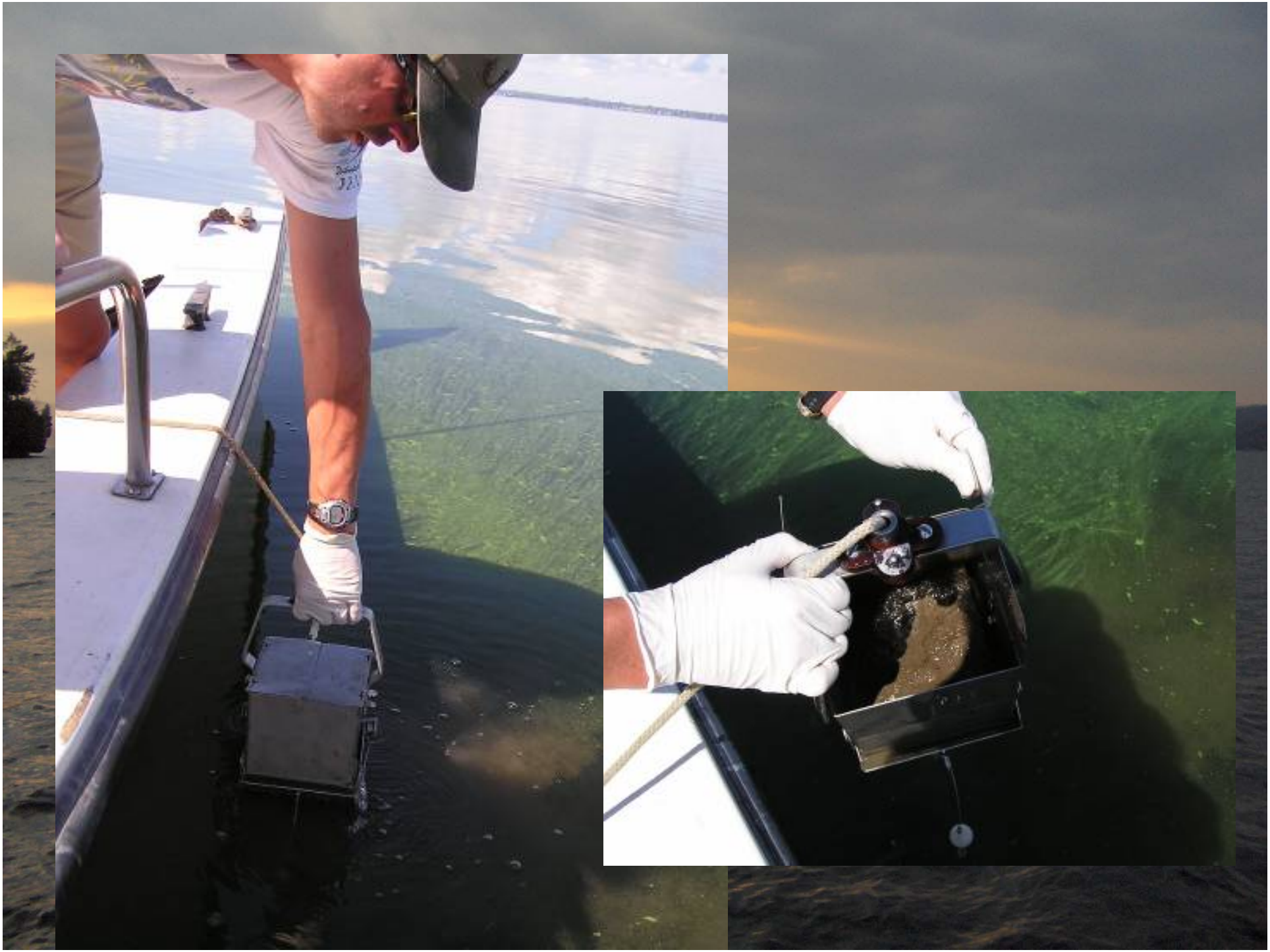
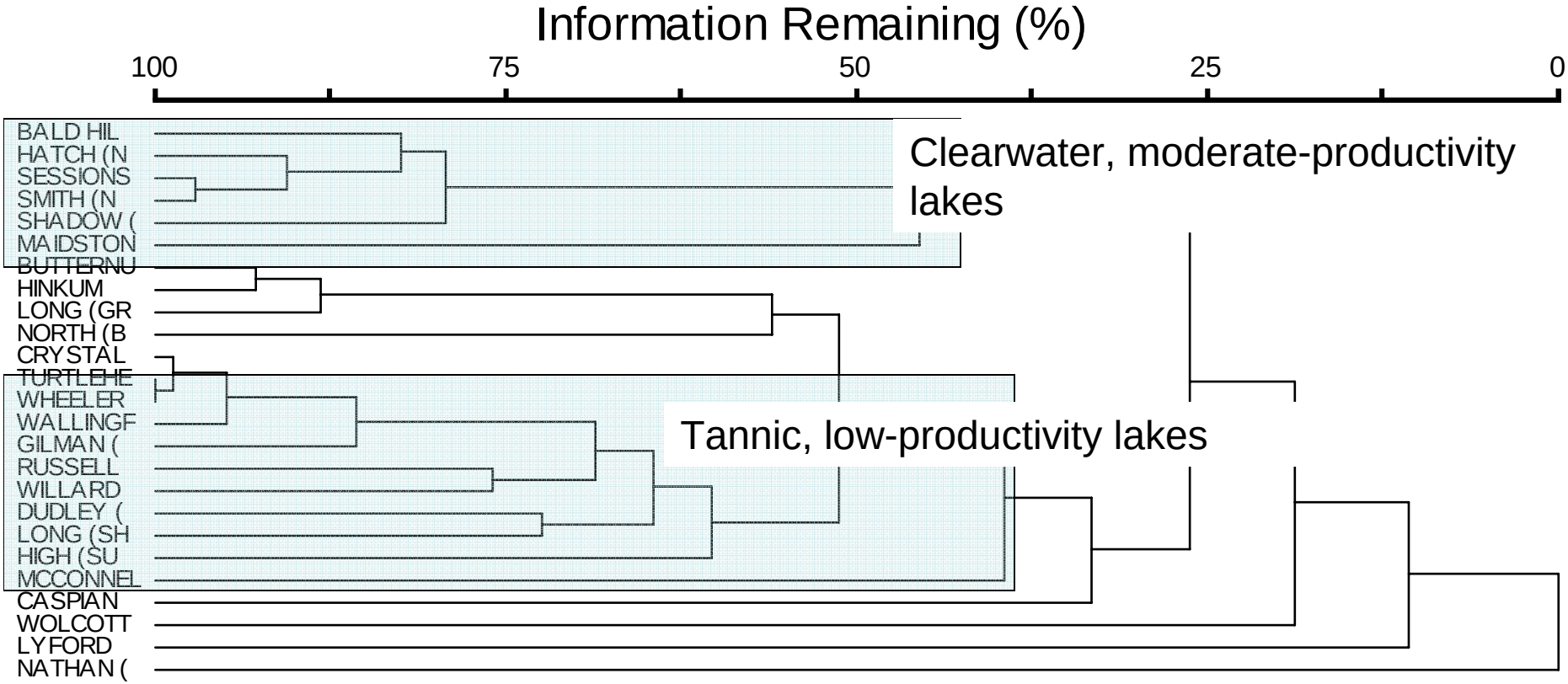


Figure 1. Example lake sampling locations

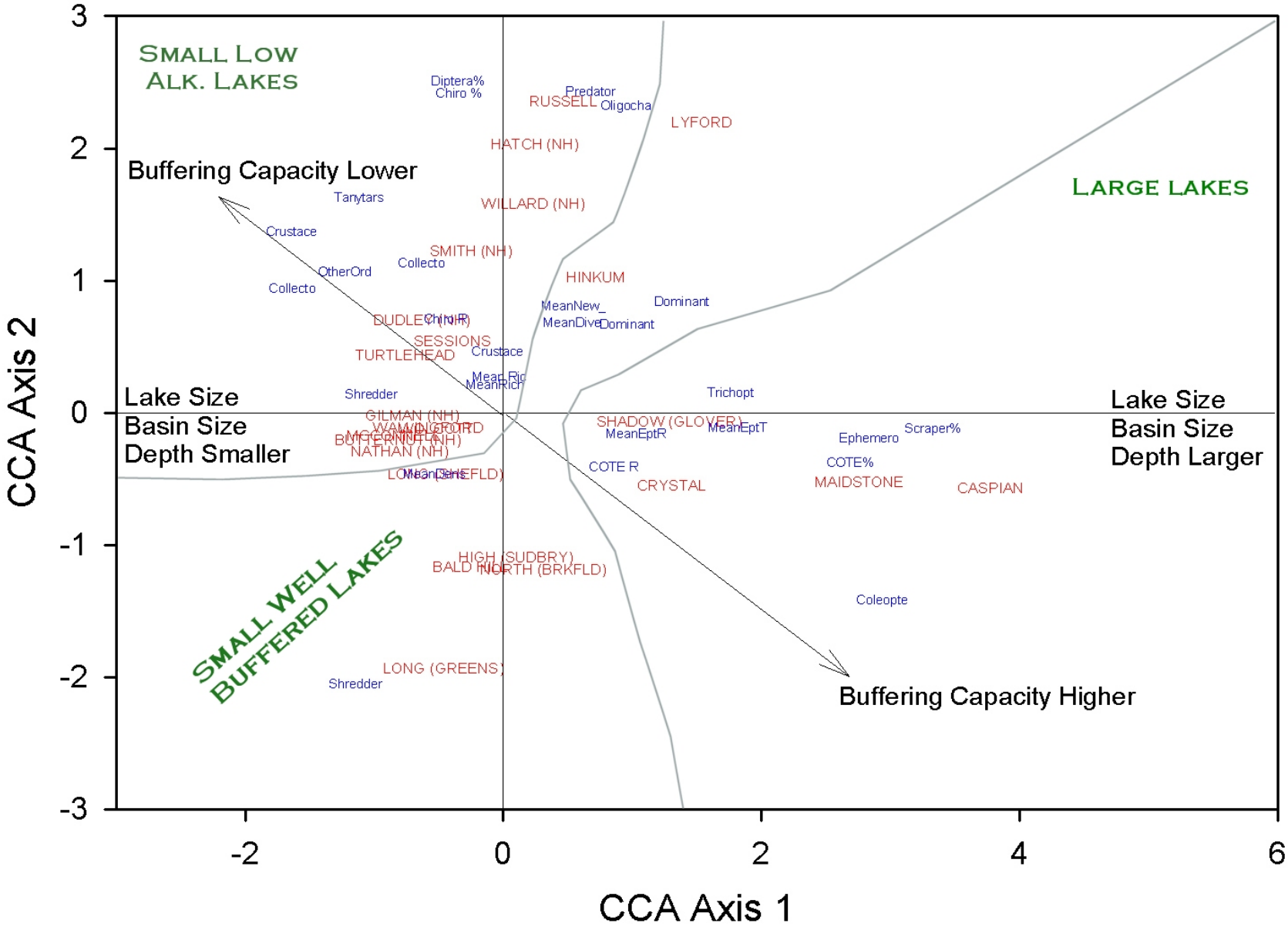


Classification of Ref. Lakes

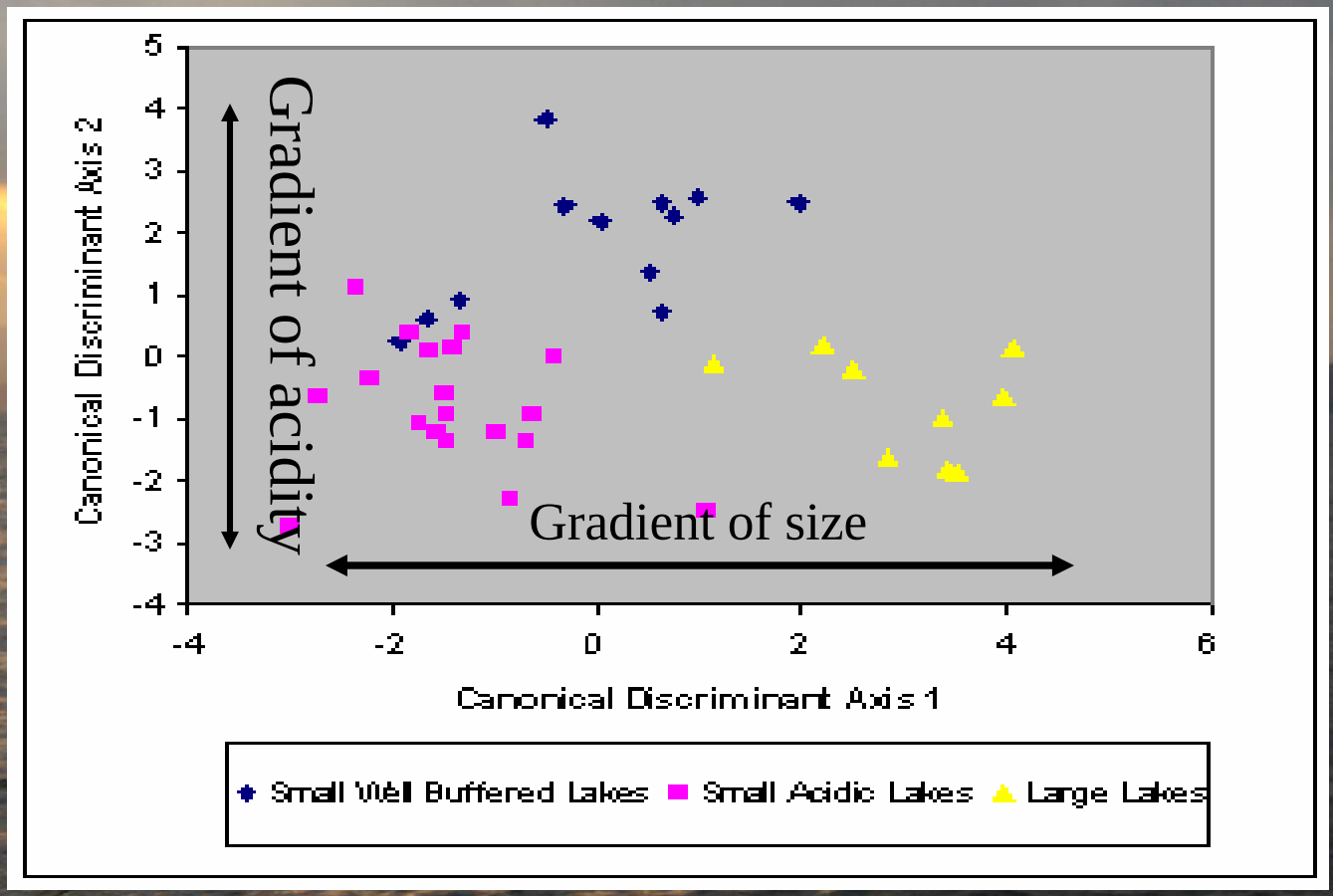


- Rocky-littoral habitat – clustering of low-productivity clearwater lakes and tannic lakes
- All habitats, clustering of tannic lakes

Classification using CCA



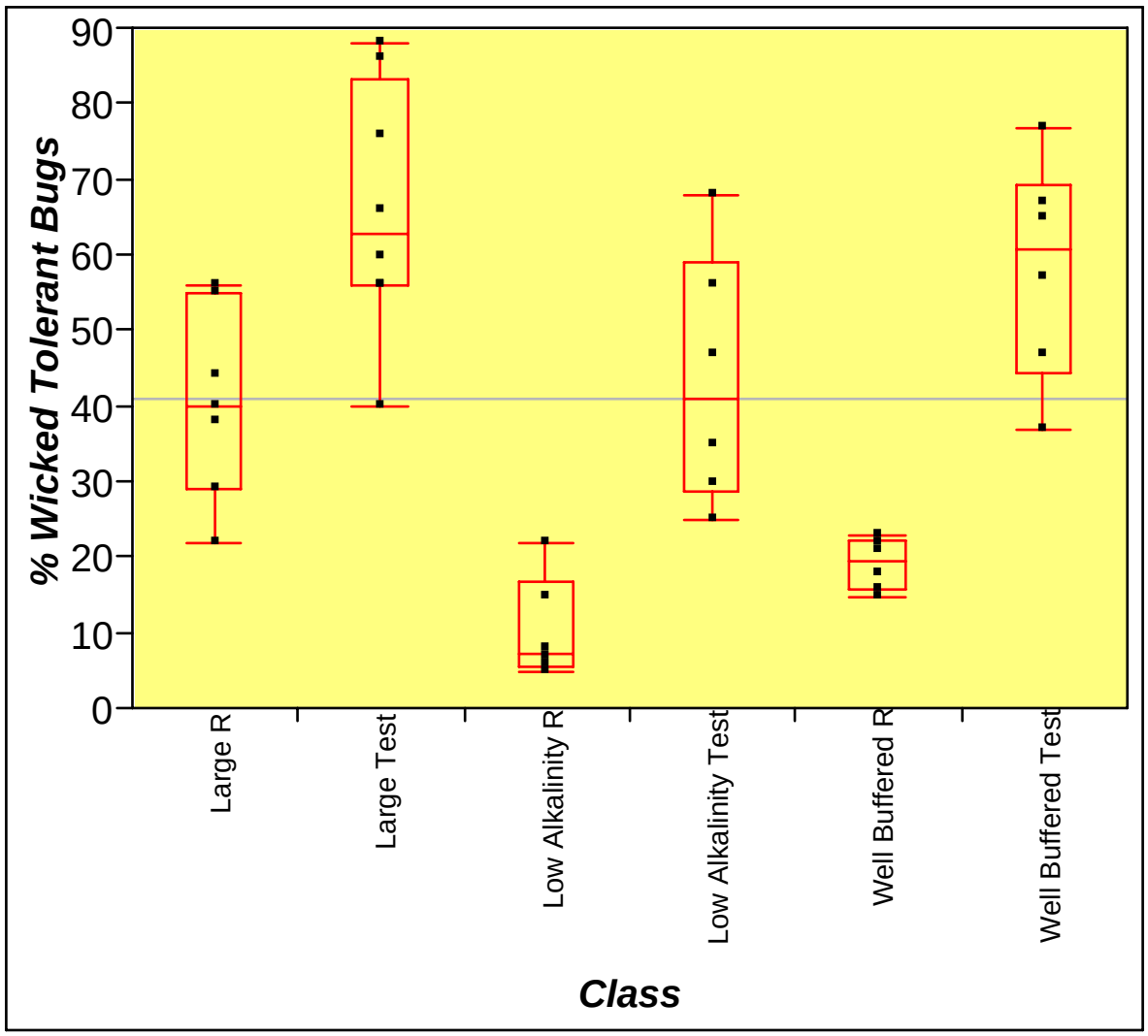
Discriminant function model



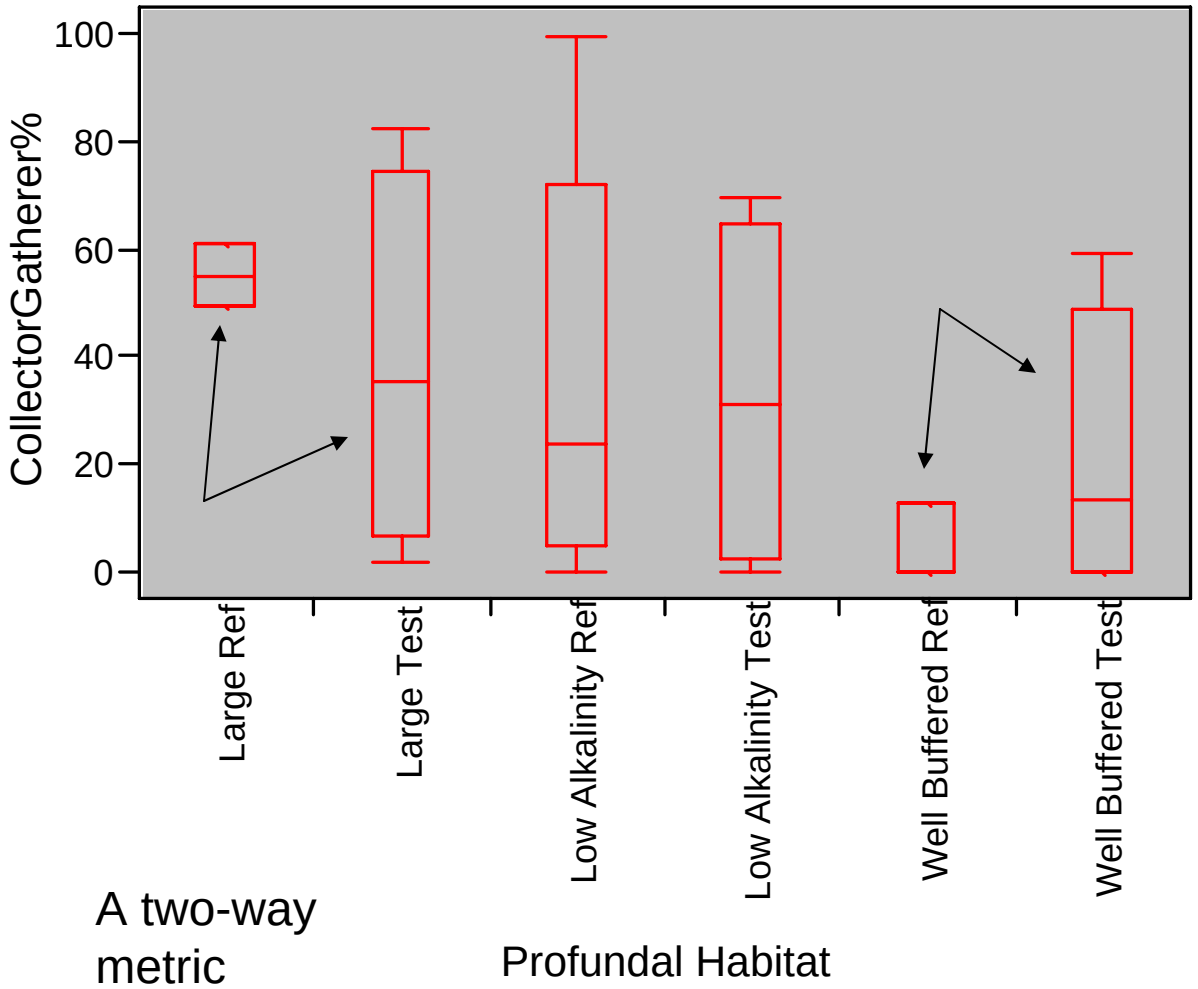
p=0.001 Overall error rate 15%

Metric selection process

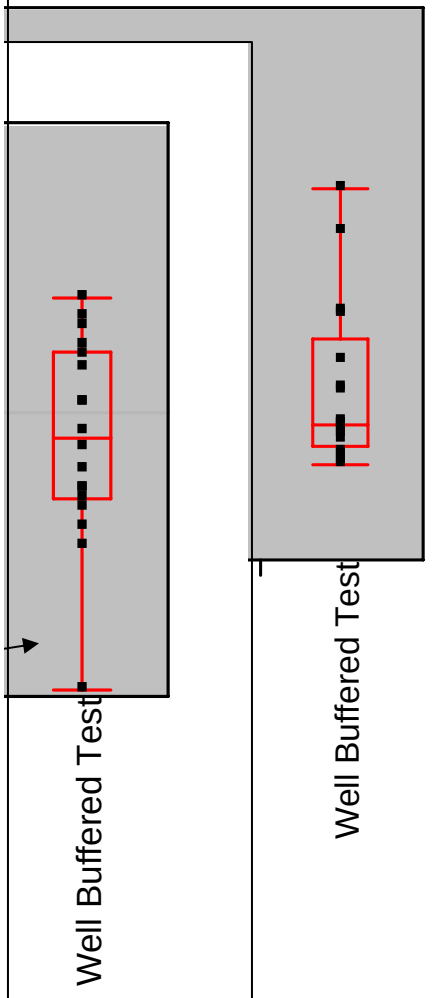
- This is the
- Plot distrib
  metrics for
- Seek out r
  and vary b



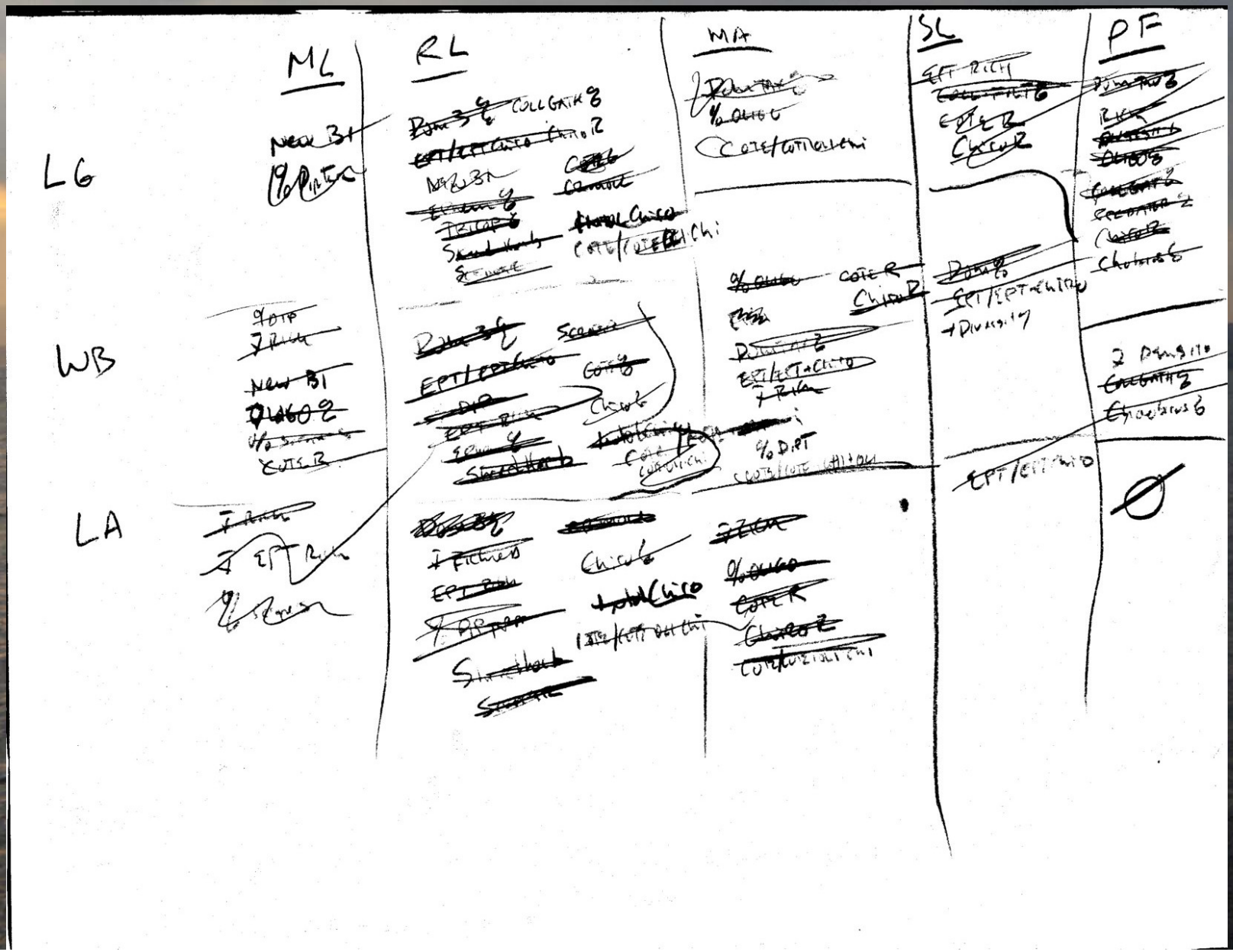
Metric selection process



A two-way metric



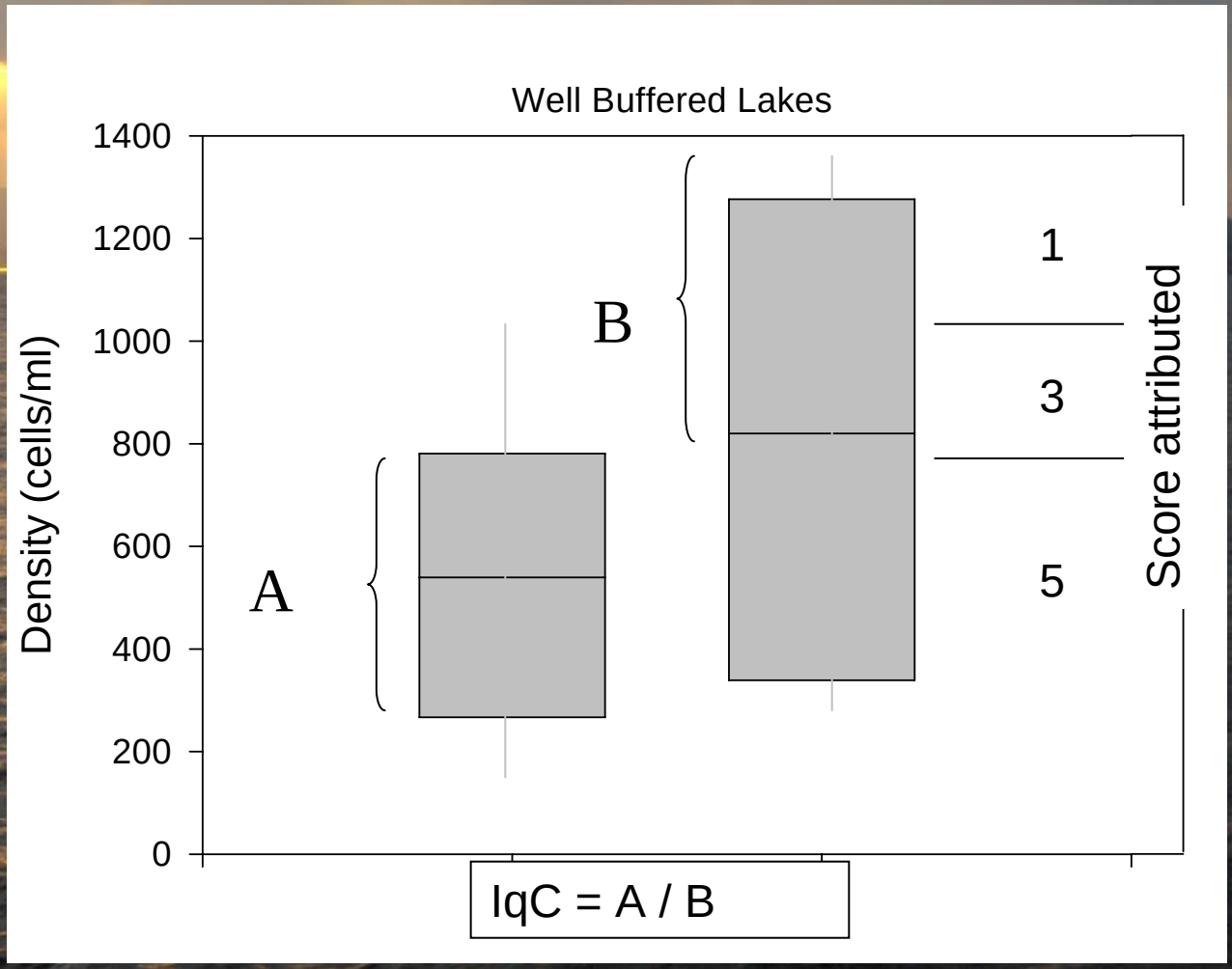
It was a very manual process



Information Content and Redundancy

- Metric quality and information content was assessed using the Interquartile Coefficient
  - IQ range of Ref / Scope for detection for test
  - Should be < 1
- Run Spearman correlations amongst identified candidate metrics within habitats
- Where metric R >0.75, reject that metric with lowest information content (largest IqC).

Example interquartile coefficient and scoring



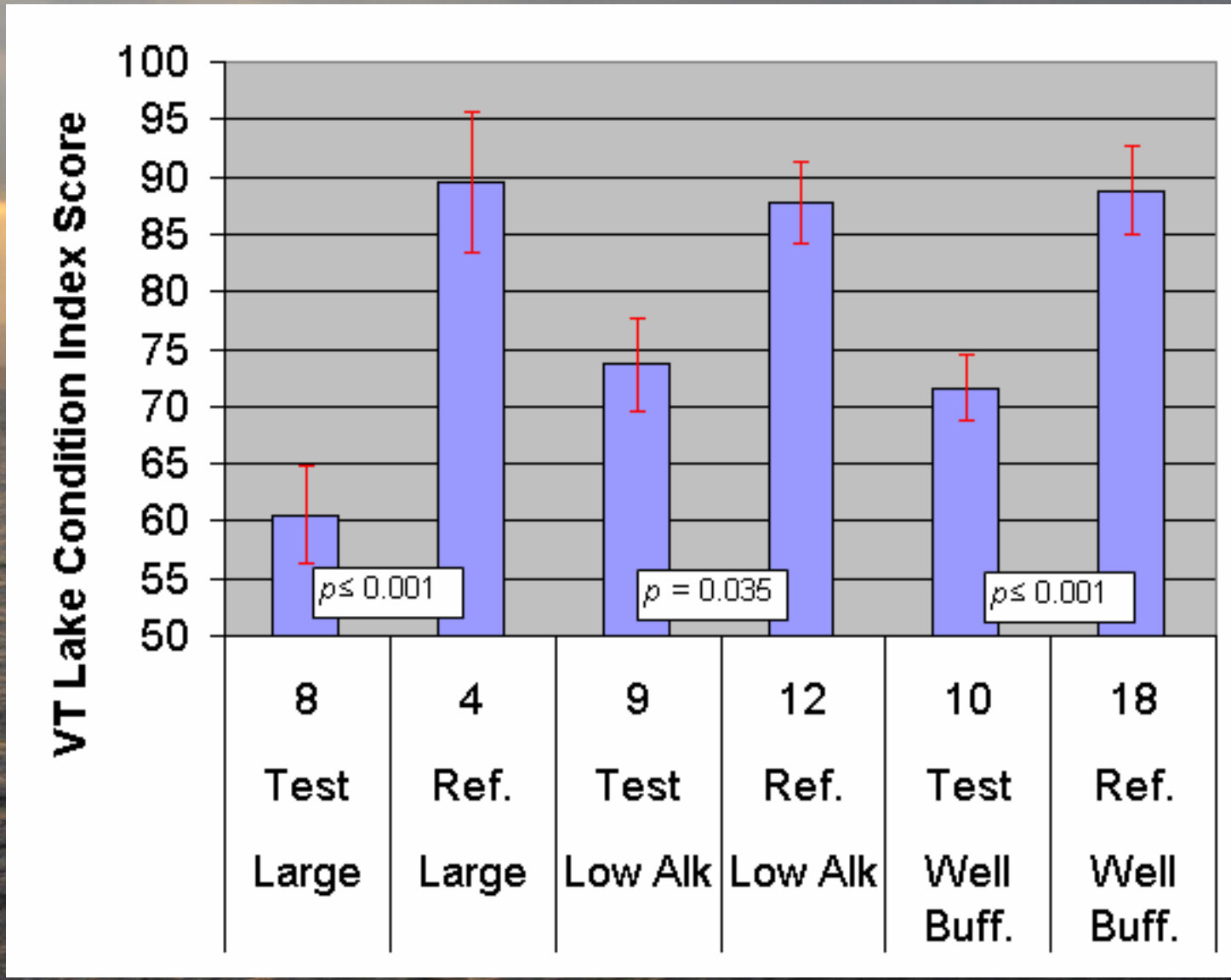
Valid metric count

Lake Class	Rocky littoral	Muddy littoral	Macro-phyte beds	Sub littoral	Prof-undal
Large	6	0	1	2	4
Low Alk.	3	1	2	0	1
Well Buffered	6	3	5	3	2
MANOVA significance	<0.001	<0.1	<0.05	NS	<0.1

Hab	Metric	Lake Class	Impact	Score Attrib.		
				IqC	5	1
PF	DOM%	Large	Elevated	0.14	<30.4	>54.7
PF	DOM%	Low Alk	Elevated	0.84	<68.4	>84.2
PF	Diversity	Large	Depressed	0.14	>2.4	<1.7
PF	Coll. Gath%	Large	Depressed	0.23	>50.0	<26.1
PF	Coll. Gath%	Well Buff	Elevated	0.29	<13.3	>36.4
PF	Chaoboridae%	Large	Elevated	0.03	<2.0	>40.5
PF	Chaoboridae%	Well Buff	Depressed	0.52	>66.0	<33.0

Scores are summed and expressed as 0% to 100% of the maximum possible score

VT Lake Condition Index Mean Scores



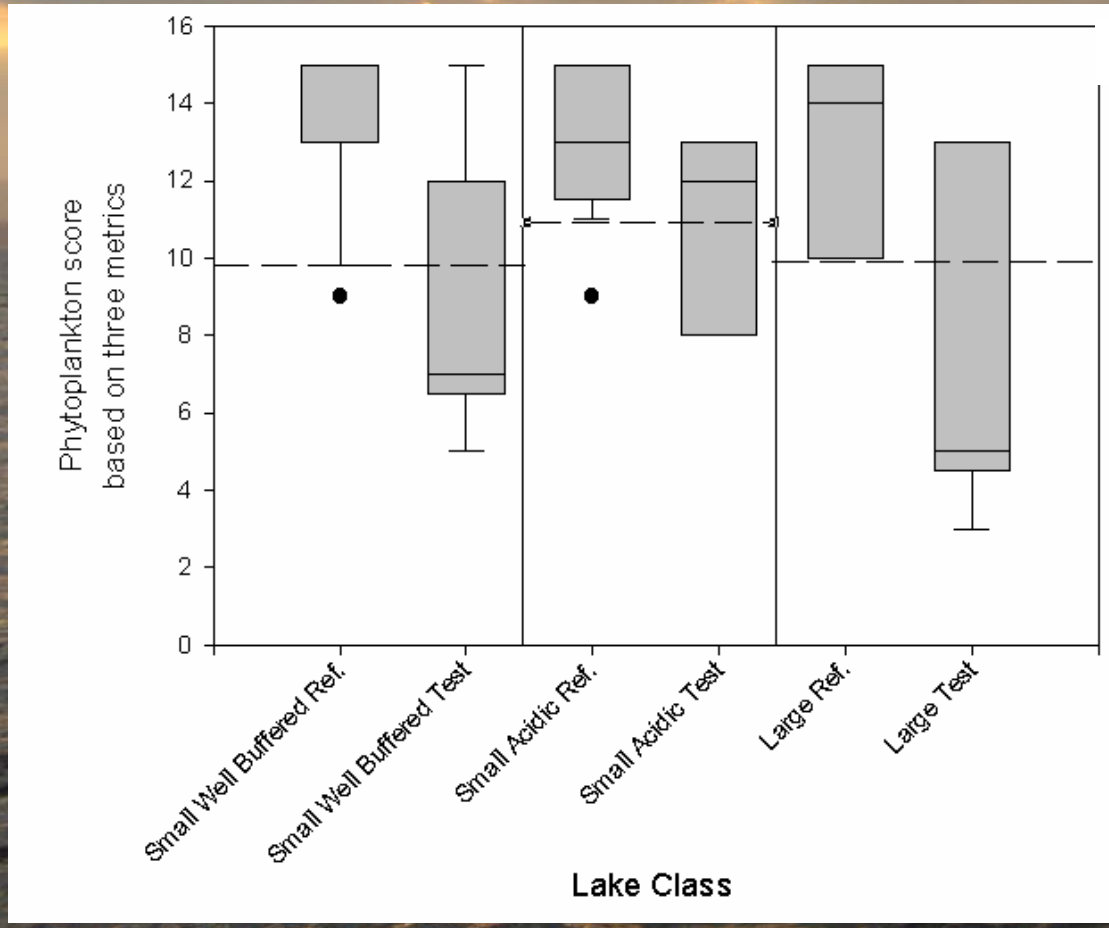
We have done this process for phytoplankton as well

- Sampling regime requires at least five biweekly samples across the growing season
- Taxonomy of 100 to 300 organisms per sample – done by contract
- Classification and metric selection process the same

Phytoplankton metrics selected

- **Total density, % *Aphanizomenon spp., Anabaena spp., Microcystis spp.* by volume**
- **for Well buffered lakes:**
  - **% chrysophytes by density**
- **for Low alkalinity lakes:**
  - **% cryptophytes by volume**
- **for Large Lakes:**
  - **% diatoms by density**

Box plots of final phytoplankton scores



Proposed Designation

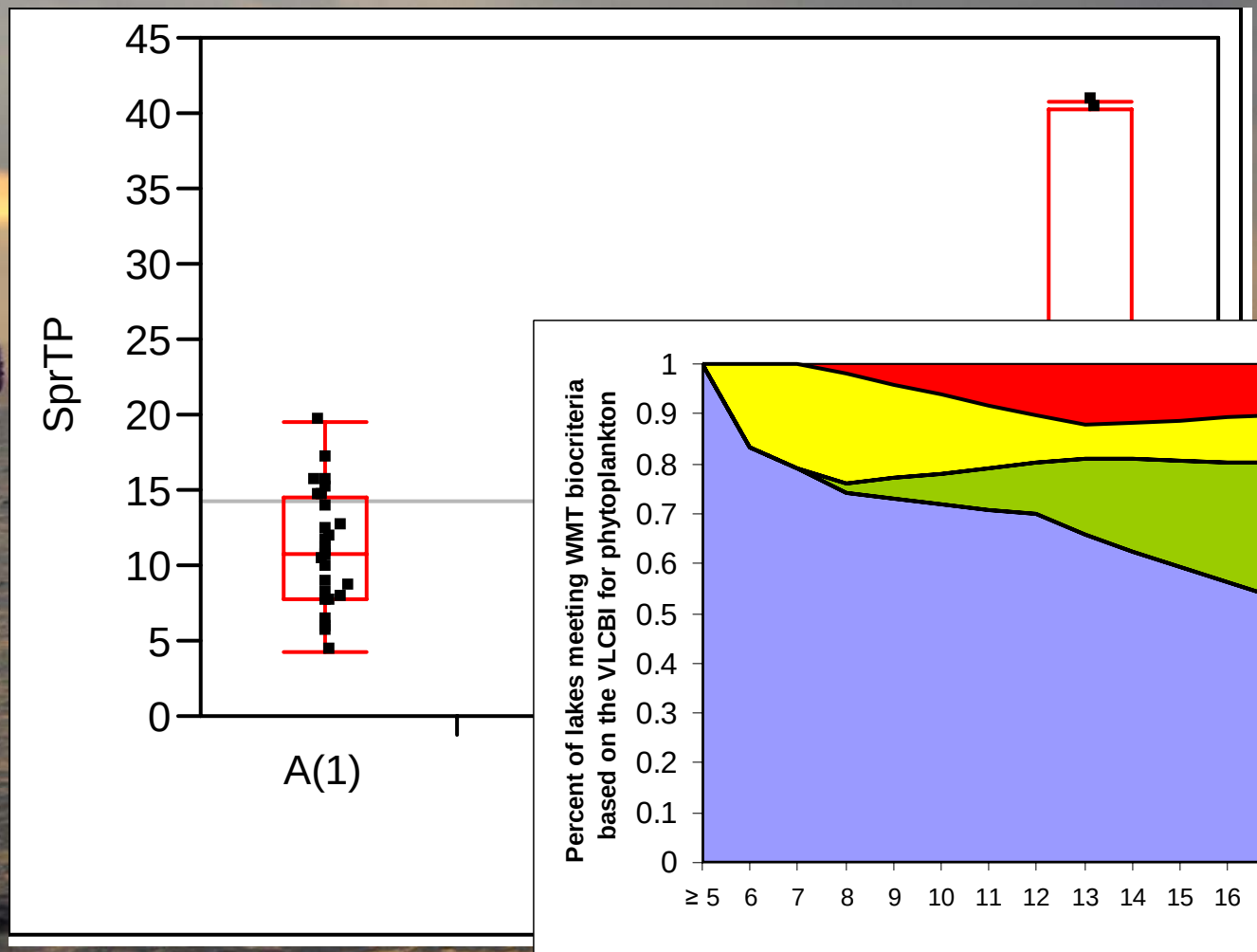
Community
meets expected reference condition for this lake type

Community
deviates significantly from expected reference condition for this lake type

Stresses detected by the IBI's

- Bug IBI
  - Cumulative development – particularly in the well buffered and large lakes
  - WL Fluctuation
  - Acidity (to a degree)
- Phytoplankton
  - Eutrophication stress
  - Useful in the development of nutrient criteria

Using the phytoplankton IBI within VT's TALU to set nutrient criteria

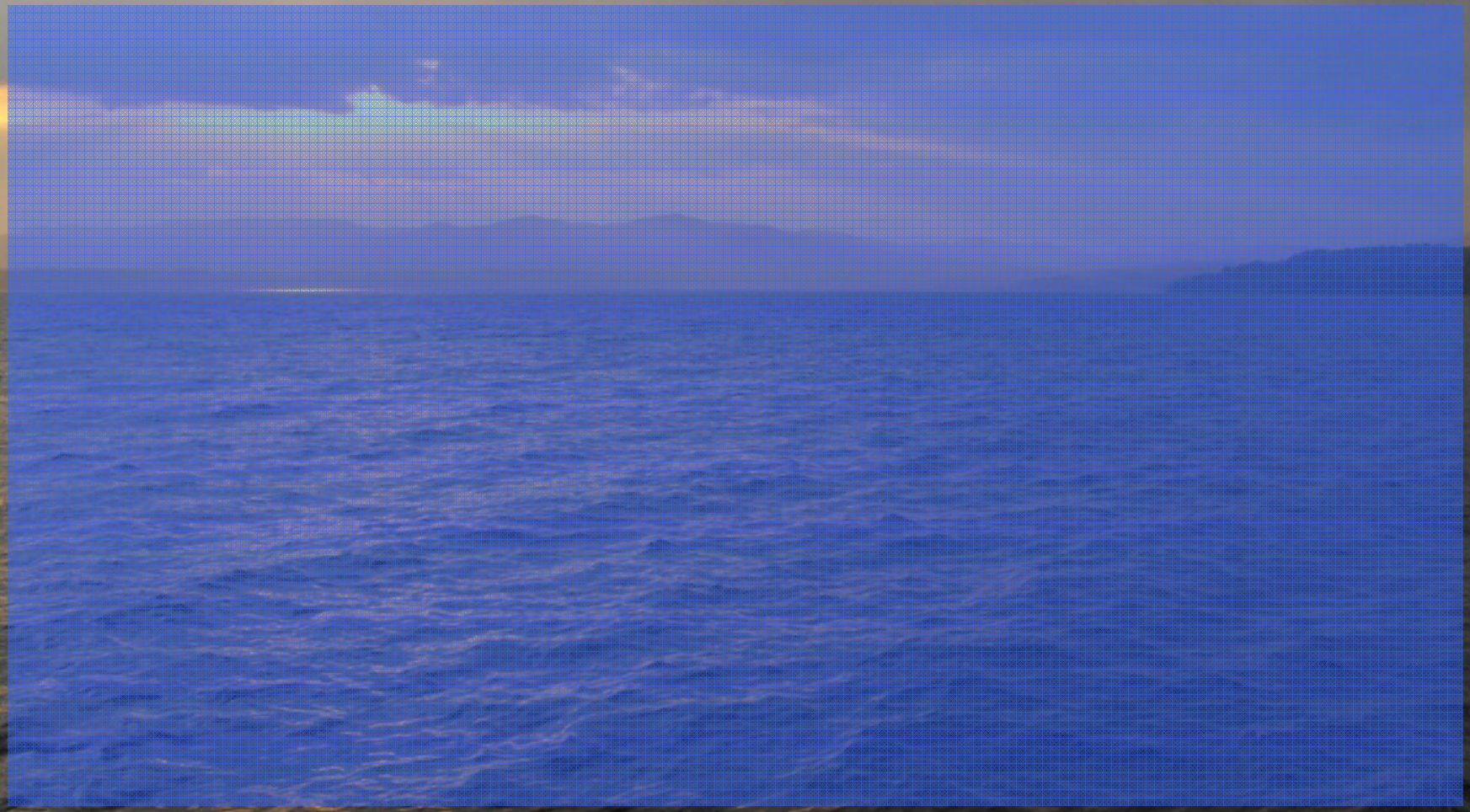


Vermont's approach to integrated assessment.

- Assess phytoplankton community using PhytoIBI
- Assess macroinvertebrate community using BugIBI.
- Assess shoreline habitat quality (ongoing work by EPA R1 and others in Northeast and Midwest).
- Measure WQ.
- When does impairment exist? ¼ endpoints failing?, 2/4?, all?

Questions?

Supplemental slides



RIVPACS – the "O/E" metric

- Essentially a richness-based supermetric
- Relates ***O***bserved taxa richness to mean richness ***E***xpected based on reference lakes
- Impact to aquatic biota evident under depressed richness
- Observed richness > reference can indicate intermediate disturbance
- Predicated on biological classification

…thank you Dr. Hawkins

Basic Concepts
(Units of Measure & the Expected Taxa)

Species	Replicate Sample Number 1	2	3	4	5	6	7	8	9	10	Freq (P_c)
A	*	*	*	*	*	*	*	*	*	*	1.0
B	*	*		*	*	*		*	*	*	0.8
C	*		*		*	*			*		0.5
D		*	*				*		*	*	0.5
E					*						0.1
Sp Count	3	3	3	2	4	3	2	2	4	3	2.9

Species Richness is the Currency.

$E = \sum P_c$ = • •number of species / sample = 2.9.

VT Approach for lakes

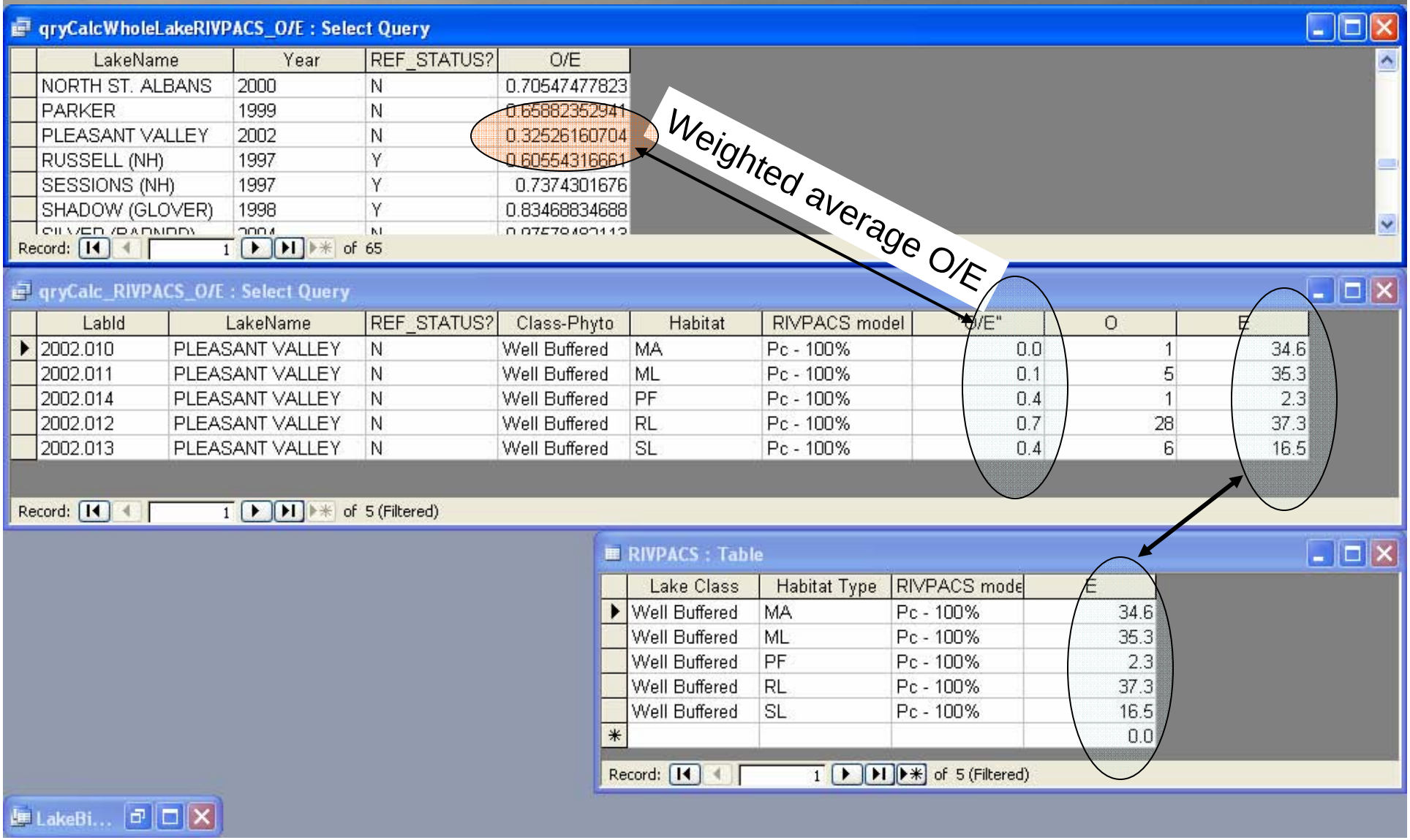
- Use existing classification
- Calculate ***E*** from ref x hab combination
- Calculate ***O*** from observed richness for each habitat surveyed, in each classified lake
- ***O/E*** for each lake therefore captures habitat sampled and classification within one apples to apples measure

O matrix

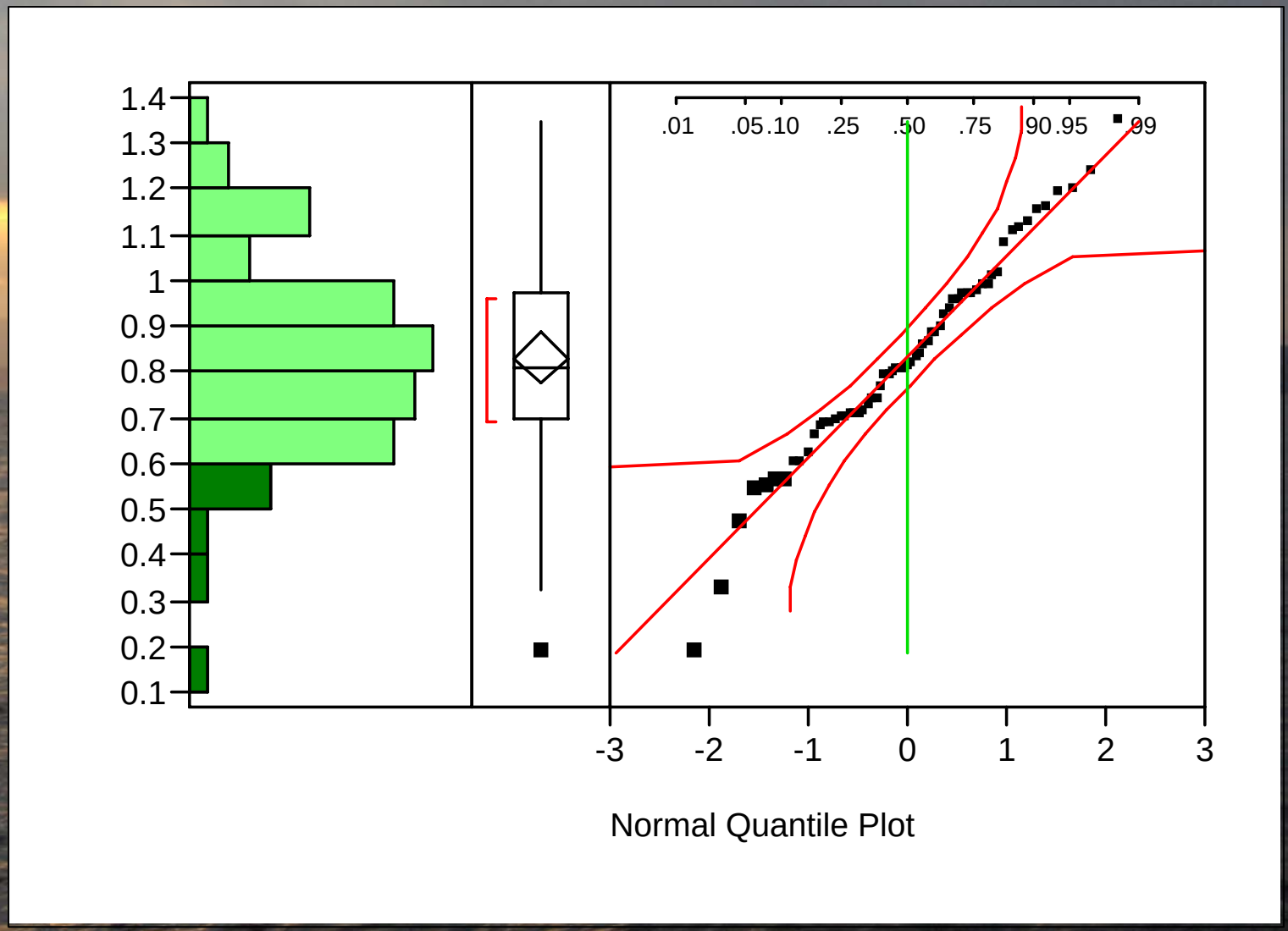
RIVPACS Worksheet					VT Lake
Lake Class	Rocky Littoral			Muddy Littoral	
	Count of Reference Lakes	Sum of Pc - All bugs	Sum of Pc >= 50%	Count of Reference Lakes	Sum of Pc - All bugs
Large	4	35.8	21.3	2	46.5
Low Alkalinity	12	34.3	10.2	12	29.4
Well Buffered	9	37.3	12.0	9	35.3

Generated a Pc>0% and Pc>50% model, used the Pc>0%

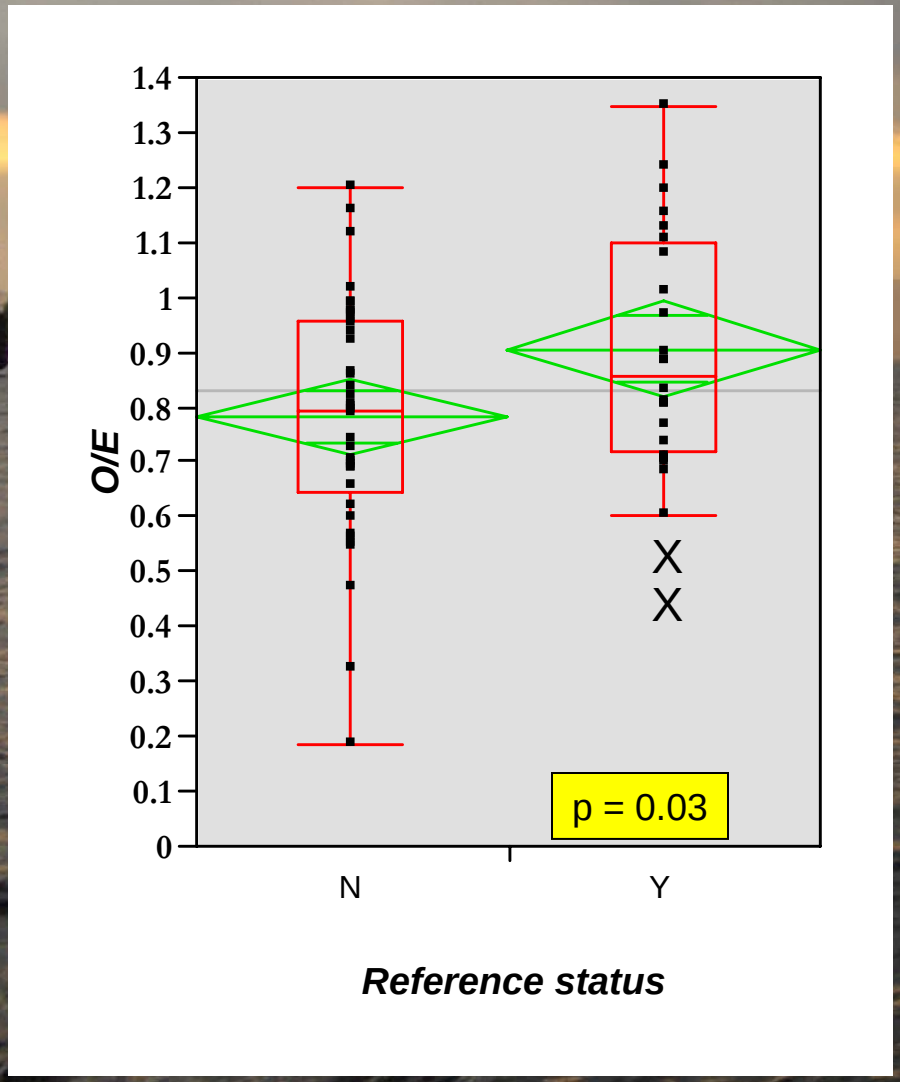
Automation of O/E Calculation



O/E Distribution for all lakes



O/E – Ref v. test lakes



- Two large, oligotrophic ref. lakes excluded from analysis
- Some “benign enrichment” evident
- O/E of 0.7 may be a good starting point for a “deviation from reference”

Lake Class	Rocky littoral	Muddy littoral	Macrophyte beds	Sublittoral	Profundal
Large	-Tricoptera% -ShredHerbiv% -COTE% -CrustMoll% -COTE/ COTE+CHI+OLI -Oligochaeta%		Oligochaeta%	Coll. Filt% ChiroR	DOM% Diversity Coll. Gath% Chaoborid.%
Low Alk	-Dom3% -ShredHerbiv% -Oligochaeta%	%Scrapers	Oligochaeta% ChiroR		DOM%
Well Buff	-3Dom% -ShredHerbiv% -COTE% -Chiro% -COTE/	%Diptera MeanRich. %Scrapers	-Oligochaeta% -COTE/ COTE+CHI+ OLI -DOM%	-DOM% -EPT/ EPT+Chiro	Coll. Gath% Chaoborid.%